E-23
Vitality Index
Maternal Vitality Index

▪ Introduction

Since 1989 the index calving ease has been calculated using birth data of cows. This index is very useful, in particular for the use of bulls on the (maiden) heifers. Research has shown, however, that, besides birth ease, also the number of live born calves per bull differs. Now, for the cattle farmer it is interesting to know which sires provide few stillborn calves. For this purpose, the vitality index has been developed. In addition, it is interesting to the cattle farmer to know which daughters of sires provide few stillborn calves. For this purpose, the vitality index for calves of daughters of sires, the maternal vitality index, has been developed. Using this information, the cattle farmer can reduce the number of stillborn calves in his herd.

▪ Data

Collection

Data have been collected from 1 January 1993, because from this date it is compulsory to issue all the live born calves in the Netherlands with ear tags and to register them with the I&R system. Due to this, a data set may be composed. In the data set a calf is considered to be stillborn, if the dam of the calf has a calving date, but no live calf is registered with the I&R system.

Data Selection

A stillborn calf is a calf that dies before, during or within 24 hours after birth, while the duration of gestation of the dam of the calf was at least 260 and 300 days at the most. In addition to this selection, the data have to fulfil the following demands:

- All multiple births are removed from the data set, because a multiple birth is a deviating birth;
- All ET calves are removed from the data set, because it is not possible to determine which maternal grandsire, that of the biological dam or of the recipient dam, must be included in the model;
- The calving age of a yearling must be at least 640 and 1075 days at the most. Animals with a calving age of less than 640 days are still young and not far developed. Due to this, these animals have less chance of a live born calf;
- The breed of the dam of the calf may not be beef. This is because beef bulls cause many Caesarean sections, when they are combined with beef cows. As a result, it is not possible to determine whether the pure beef calf would also have been born alive in a natural manner;
- Sire and maternal grandsire of the calf must be known;
- The dam of the calf must have an S registration.

▪ Statistical Model

The calculation of the breeding values is done with an animal model, in accordance with the BLUP technique (Best Linear Unbiased Prediction). Two models are used, one for heifers and one for older cows. Two models are used, because vitality is a different trait for heifers than for older cows. The models differ in the fact that for the heifers the effect of calving age is included, whereas for the older cows this effect has been replaced by parity. The statistical model through which the breeding values for vitality is estimated is:

For heifers:

$$Y1_{ijklmnopqs} = CG_i + YM_j + AGE_k + HETcow_l + RECcow_m + HETcalf_n + RECcalf_o + COW_p + CALF_q + E_s$$

For cows:

$$Y2_{ijklmnopqrs} = CG_i + YM_j + PAR_k + HETcow_l + RECcow_m + HETcalf_n + RECcalf_o + COW_p + CALF_q + PERM_r + E_s$$

In which:

$Y1_{ijklmnopqs}$: Vitality at birth of calf *q* to heifer *p* in management group *i*, born in year x month *j*, with age *k*, where heifer *p* has heterosis *l* and recombination *m*, and where calf *q* has heterosis *n* and recombination *o*;
$Y2_{ijklmnopqrs}$: Vitality at birth of calf *q* to cow *p* in management group *i*, born in year x month *j*, with parity *k* and with permanent environment *r*, where cow *p* has heterosis *l* and recombination *m*, and where calf *q* has heterosis *n* and recombination *o*;
CG_i : Herd or management group *i*;
YM_j : Year x month of birth *j* of the calf;
AGE_k : Age at calving *k* of the calf *p*;
PAR_k : Parity *k* of cow *p*;
$HETkoe_l$: Heterosis *l* of cow *p*;
$RECkoe_m$: Recombination *m* of cow *p*;
$HETkalf_n$: Heterosis *n* of calf *q*;
$RECkalf_o$: Recombination *o* of calf *q*;
COW_p : Additive genetic effect of cow *p* or the maternal effect;
$CALF_q$: Additive genetic effect of calf *q* or the direct effect;
$PERM_r$: Permanent environment effect *r* of cow *p*;
E_s : Residual of Y1 or Y2, which is not explained by the model.

The effects COW_p, $CALF_q$, $PERM_r$ and E_s are random effects, heterosis and recombination are co-variables and the other effects are included in the model as fixed effects.

Effects in the Model

Management Group
For the heifers, per herd, 20 consecutive calvings form a management group. If three years after the first heifer of a group has calved the number of 20 has not yet been achieved within the group, the management group is closed after all. For the older cows, 30 cows form a management group. In figure 1 the frequency distribution of several management groups per percentage of live born calves is displayed. It concerns here rough averages. The figure shows that there is a large variation between the management groups.

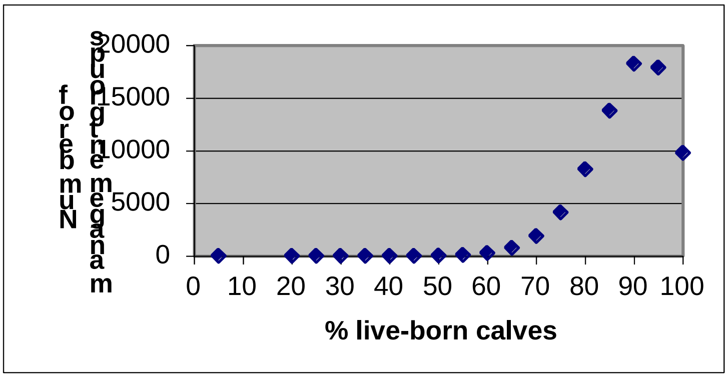

Figure 1. Frequency of the number of management groups per percentage of live born calves from heifers

Year x month of birth
The percentage of live born calves appears not to be the same in each month. For example, fewer live calves are born to heifers in the winter months than in the summer months. Figure 2 shows that this pattern is not the same over the years. The differences for cows are smaller than those for heifers. The percentage of live born calves per year x month is between 94 and 96% for cows. For heifers, the differences per year x month are greater. The percentage of live born calves for heifers was highest in 1995, with 91%, and lowest in 2010, with 81%. This is the reason why year x month is included in the model.

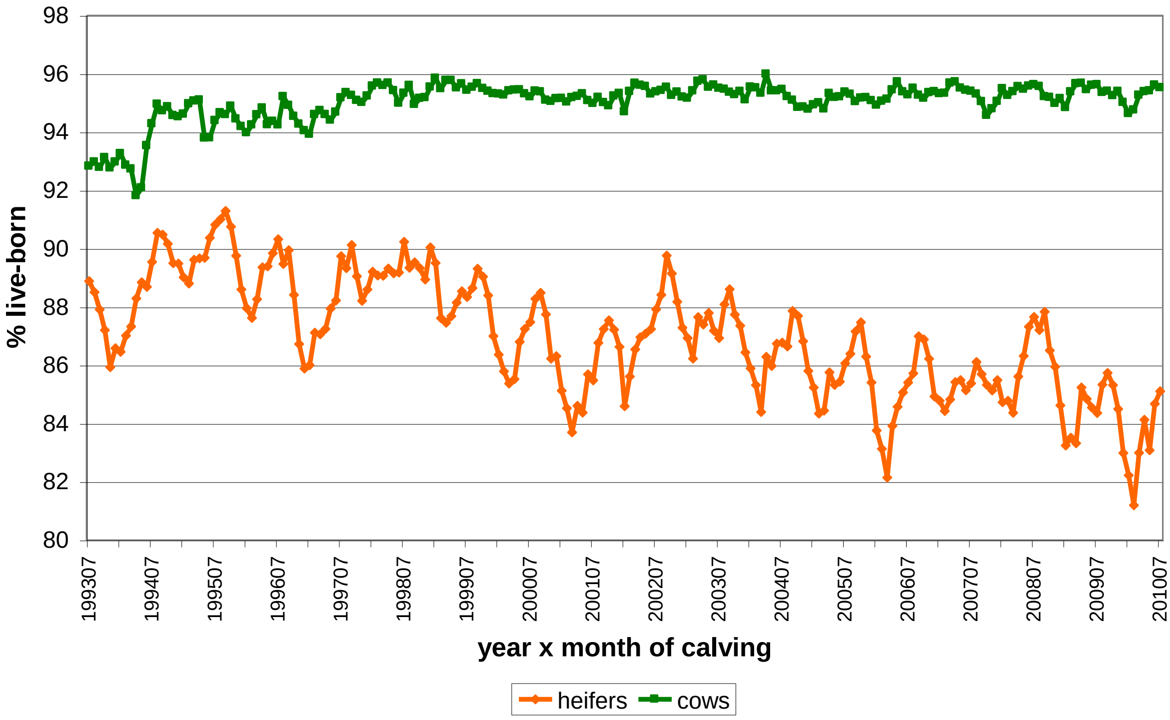

Figure 2. Percentage of live born calves in heifers and cows charted against months

Age at calving of heifers
Animals that calve at a young age, have less chance of a live born calf than animals that calve at an average life. One of the reasons is that de development of the birth channel and the size of the calf are not yet mutually tuned in. Heifers that calve at a late age have less chance of a live born calve too. One of the reasons is that the elasticity of the pelvis of these animals has decreased due to fat covering. Between heifers calving at the age of 22 months or younger and heifers calving at the age of 29-33 months, there is a difference of 3 percent in the percentage of live born calves.

Figure 3. Effect of calving age on percentage of live born calves

Parity

Figure 4 displays the percentage of stillborn calves per parity. This figure shows that the parities 2 to 7 and higher do not have the same percentage of stillborn calves. Because of this fact, parity of cows is included in the model.

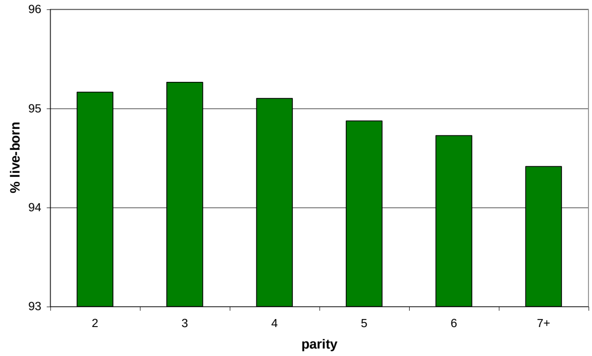

Figure 4. Effect of parity on percentage of live born calves

Heterosis and recombination

Heterosis and recombination effects play a role in the combining of breeds. These are genetic effects that are not transmitted to the offspring. Research has shown that a correction must be made to these effects.

The amount of the heterosis is defined as the difference in level or the trait in the crossing with the average of the parent breeds. Recombination is the loss of the usually positive effect of heterosis and occurs when the earlier achieved crossing product is crossed back with one of the parent breeds.

Heterosis plays a role in heifers in particular. In calves with 100% heterosis, 0.6% more calves are live born. In heifers with 100% heterosis, 0.9% more calves are live born.

Additive genetic effect for the cow or maternal effect

The additive genetic effect of the cow is the maternal breeding value, the effect that matters in the end. The variable cow contains the (genetic) contribution of a cow to the observation and determines the maternal breeding value of an animal. This concerns only the effect of the dam as the carrier of the calf and not the dam as a genetic component of the calf. The effect depends on factors such as good preparation for the birth process and the conditions in the uterus at the end of gestation. The maternal effect indicates the extent to which cows are capable of giving birth to viable calves. All of the information concerning ancestors and progeny is also used in determining the breeding value. The heritabilities used are shown in Table 1.

Additive genetic effect for the calf or direct effect

The additive genetic effect of the calf is the direct breeding value, the effect that matters in the end. The variable calf contains the (genetic) contribution of a calf to the observation and determines the direct breeding value of an animal. All of the information concerning ancestors and progeny is also used in determining the breeding value. The heritabilities used are shown in Table 1.

Permanent environment effect
A cow can calve several times in her life. The observations within a cow have more in common than genetics. This additional agreement is called permanent environment effect, an effect of the constant conditions in which a cow is kept. By using a permanent environment effect in the model, several observations on an animal can be used in order to obtain a better estimate of the breeding value. The repeatabilities used are shown in Table 1.

▪ Parameters

Two traits are analysed in the breeding values estimation: vitality in heifers and vitality in cows. These traits are analysed as correlated traits. Because both cow and calf are involved in the birth, an additive genetic effect is estimated for both animals. As a result, two breeding values are obtained for each trait: the direct effect for the calf and the maternal effect for the cow. In the end, breeding values are estimated for four traits. Table 1 shows the heritability, repeatability and genetic standard deviation for each trait. Heritability is a measure of the fraction that is explained by genetics. Repeatability indicates the part of the observation on an animal that corresponds with a subsequent observation on the same animal. Table 2 shows the genetic correlations.

Table 1. Heritability (h^2), repeatability and genetic standard deviation for vitality (1 = heifers, 2+ = cows)

trait	h^2	repeatability	genetic standard deviation	unit
maternal vitality 1	0.084		10.63	%
maternal vitality 2+	0.005	0.033	1.49	%
direct vitality 1	0.039		7.48	%
direct vitality 2+	0.005	0.033	1.63	%

Table 2. Genetic correlations for vitality (1 = heifers, 2+ = cows)

	maternal vitality 1	maternal vitality 2+	direct vitality 1	direct vitality 2+
maternal vitality 1				
maternal vitality 2+	0.545			
direct vitality 1	-0.091	0.241		
direct vitality 2+	-0.001	0.101	0.669	

▪ Publication

The bull breeding value for vitality is published as a relative breeding value; the average is 100 and a standard deviation of 4. The breeding values based on heifer data are published, because most dead calves are born to heifers. Table 3 shows the effect of a breeding value of 104 on the progeny of a bull mated with an average cow. The transmitting ability is calculated as half the breeding value and indicates the effect on the offspring.

Table 3. Effect of relative breeding values vitality at first and higher parities (1 = heifers, 2+ = cows)

trait	Relative breeding value	Transmitting ability (effect on progeny)	Unit
maternal vitality 1	104	4.76	%
maternal vitality 2+	104	0.63	%
direct vitality 1	104	3.35	%
direct vitality 2+	104	0.60	%

There is a clear difference between the effect of vitality in heifers and at higher parities. A breeding value of 104 for direct vitality means that heifers will have around 3.35% more live born calves from a bull and the combination of the same bull with older cows will give around 0.60% more live born calves from the same bull. A breeding value of 104 for maternal vitality means that the female offspring of a bull will have 4.76% more live born calves as heifers and 0.63% more live born calves as older cows.

The breeding value for both direct and maternal vitality is published for AI bulls if the reliability of the breeding value is at least 25%. For tested AI bulls, the breeding value must be based on at least one offspring. For untested AI bulls, there is a minimum requirement of 10 offspring. See chapter E-26 for further information on publication rules.

▪ Base

Breeding values for the vitality traits are published based on the 2015-base. Cows born in 2010 determine the base of 2015. There are four different bases: Milk goal Black, Milk goal Red, Dual purpose and Belgian Blue. The definitions of these bases are as follows:

Milk goal Black (Z)
Herdbook-registered animals born in 2010 with at least 87.5% HF-blood and up to 12.5% FH-blood and hair colour black pied, with at least one observation in the genetic evaluation.

Milk goal Red (R)
Herdbook-registered animals born in 2010 with at least 87.5% HF-blood and up to 12.5% MRY-blood and hair colour red pied, with at least one observation in the genetic evaluation.

Dual purpose (D)
Herdbook-registered animals born in 2010 with at least 75% MRIJ-blood and 25% or less HF blood, with at least one observation in the genetic evaluation.

Belgian Blue (B)
The Belgian Blue base is determined by the animals that determine the Dual purpose base.

An observation is an animal's calving or an animal's birth.

The distribution of breeding values is determined by the Milk goal Black base animals. The distribution in breeding values is calculated and standardised to a reliability of 80 percent.

This means that 4 points of distribution is equivalent to 0.9 x genetic distribution. The advantage of a single distribution for all bases is that there is only a difference in level between the bases, and no difference in distribution.

Every five years, in a year divisible by 5, the reference year for the base is moved 5 years.

The base differences are shown in Table 4. The base differences of the Dual purpose base also applies on the Belgian Blue base.

Table 4. Base differences for vitality traits (1 = heifers, 2+ = cows)

	Z → R	*Z → D*	*R → D*
maternal vitality 1	1	-2	-3
maternal vitality 2+	0	-2	-2
direct vitality 1	-2	0	2
direct vitality 2+	0	2	2